FreeRehab

A traumatic event affecting the musculoskeletal system forces a person to a period of immobilization. With the rehabilitation process, the therapist has to bring the patient to a complete recover of both joint functionality and muscle strength and get him ready to return to his normal daily activities. Moreover, if the patient is an athlete, the rehabilitation program has to ensure an early and safe return to sport. FreeRehab is the technological solution born to provide the therapist with objective data characterizing the functionality of an injured joint over the whole rehabilitation program.

FreeRehab allows the assessment of joint mobility and muscle strength providing evidence to clinical decision making and assisting doctors and therapists in objectively monitoring the progresses of the recovery and the efficacy of the therapy.

FreeRehab is based on an inertial sensors system connected wirelessly to a software via Bluetooth communication. The software consists of a module for the assessment of joint mobility (Range of Motion, ROM) and a module for the assessment and monitoring of muscle strength (Strength Recovery, SR). Depending on the typology of evaluation, the device can be positioned on a body segment using a specifically designed support (ROM module) or on the weight stack of any muscular machine through a magnetic pocket (SR module). The user is free to choose his own testing protocol for the assessment of joint mobility and muscle strength: sensors data are sent wirelessly in real-time to the software which shows to the user the parameters characterizing the functionality of the injured joint.

Technical features

The hardware:

- Scientifically-validated inertial sensors system;
- Pocket-sized and lightweight;
- Long duration battery (over than 24 h);
- Wireless Bluetooth communication

The software:

- Scientifically-validated computational algorithms;
- Real-time data (graphs and numerical indicators);
- User-friendly interface, intuitive database and personal data research;
- Export of the evaluation report in a PDF format;
- Modular architecture for the software.

Functionality

With FreeRehab the therapist will be able to:

- perform a preliminary evaluation of the physical condition of the injured person by filling the assessment questionnaires recommended by the international scientific community;
- quantify the deficit of mobility between the injured joint and the healthy one;
- quantify the deficit of muscle strength between the injured joint and the healthy one;
- keep track of the pain perceived by the patient in correspondence to each evaluation;
- monitor in real-time muscle power exerted by muscles through a visual bio-feedback during resistance training exercises performed using the injured joint;
- report the recovery progress during every stage of the rehabilitation;
- share the relevant report with the patient and the reference doctor.

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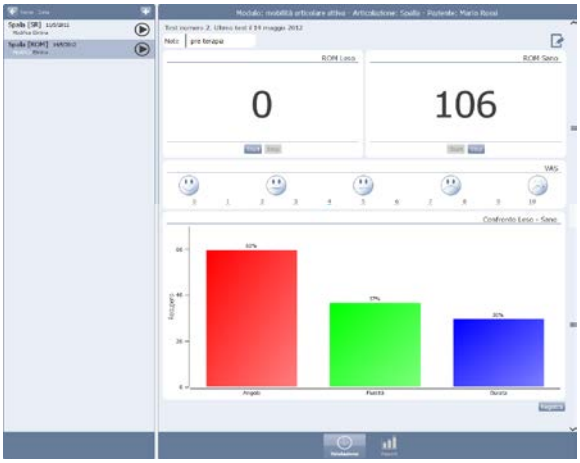
Software Modules

- Range of Motion [ROM]
- Strength Recovery [SR]

Range Of Motion

This module has been designed for assessing the mobility of an injured joint. The evaluation consists in performing a joint mobility test chosen by the therapist (e.g. shoulder abduction) which has to be carried out both with the injured joint and the healthy one. The sensor unit is placed on the body segment which rotates around the injured joint using a specifically designed support. Functionality of the injured joint is expressed in percentage of the performance of the healthy joint and is characterized by three parameters:

1. range of motion
2. movement fluidity
3. movement duration



The evaluation can be, then, concluded by adding the pain perceived by the patient during the execution of the movement using the Analog Pain Scale (VAS).

ROM module of FreeRehab does not simply characterize joint mobility in terms of range of motion: movement fluidity is a specifically designed index for revealing the eventual presence of alterations (e.g., tremors) during the execution of the movement, caused by pain or morphological impediments. Finally, percentage difference of movement duration is computed with respect to the range of motion covered by the injured joint.

The reporting functionality of the software allows the therapist to keep track of the progresses of the recovery by showing results grouped by date of evaluation.

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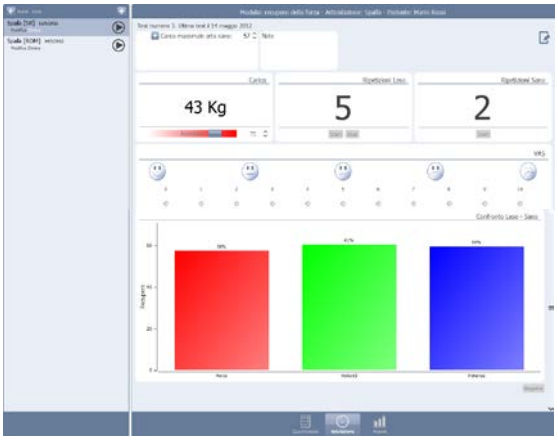
Strength Recovery

Strength Recovery module is based on resistance training (iso-inertial) tests involving muscle groups of the injured joint. This module aims at:

1. quantifying the difference, in terms of force, power and velocity, between the healthy limb and the injured one
2. identifying the right load and exercise intensity which will be used during the rehabilitation process for filling the gap between the injured limb and the healthy one

Testing protocols (muscular machine to be used, loads to be managed, number of weightliftings to be performed etc) are decided by the therapist: once the theoretical one repetition maximum (1RM) relative to the healthy limb is inserted, the software allows the therapist to choose the load to administer to the injured limb in percentage of 1RM.

Fixed percentages of 1RM can be, then, progressively administered both to the injured and healthy shoulder to find the early load at which a certain difference (decided by the therapist) of force and power can be noted. Once this load is identified, the software will then assist the therapist in monitoring the subsequent resistance training phase providing a real-time visual feedback on the intensity of the exercise. Strength tests can be performed at any time of the rehabilitation process for quantifying the improvement of the patient and the effectiveness of the methodology adopted by the therapist. This will be helpful for the decision making process.



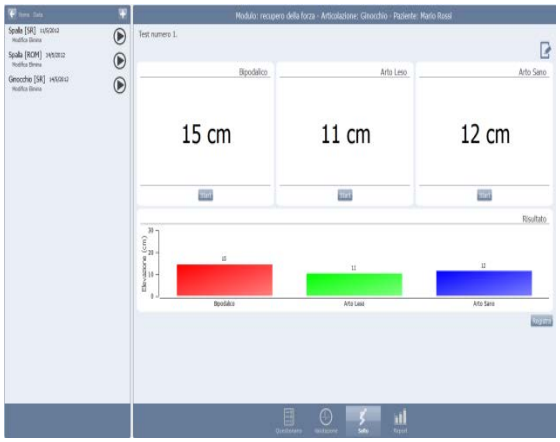
Results, relative to resistance training test, are characterized by three indicators:

1. force
2. power
3. velocity

which are shown to the user in percentage of the performance of the healthy limb.

The therapist ends the evaluation by adding in the Analog Pain Scale (VAS) the pain perceived by the patient during the execution of the movement.

During the last part of a rehabilitation course involving joints of the lower limb, the therapist may decide to assess strength deficit in a functional way using the vertical jump test. A positive outcome of this test might be the hint for the therapist to pass the patient back in the hands of the physical trainer. Vertical jump test consist in performing a double-leg countermovement vertical jump, followed by two single-leg jumps (healthy and injured limb).



The relevant indicators of this test session are:

- absolute elevation, expressed in centimeters, relative to the double-leg jump
- elevation relative to the jump performed with the injured limb expressed in percentage of the healthy limb.

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According to the protocol, the sensor unit can be placed on the weight stack of any resistance training machine by means of a magnetic pocket or worn by the athlete using a neoprene belt (jump tests). The sensors unit measures the acceleration impressed by muscles to the weight stack during resistance training exercises or to the center of mass of the subject during a vertical jump.

Therefore, the report area traces the percentage of the recovery progress of the injured limb through the above fundamental parameters (strength, speed, power and elevation).

In particular the evaluation report can be issued in relation of two variables: the time of recovery and the load.

In the first case the report shows the last tests carried out with all the loads used during the entire rehabilitation course.

In the other case the physioterapist can visualise all the tests performed by using a specific load: basing on those data, he consequently decides in safety when it will be possible to test and to exercise the patient in safety with heavier loads.

The VAS values are registered in every test and appear in both the above versions: if the variable is time of recovery, the value associated to the last evaluation test is an average of the values registered in all the tests carried out with that load.

The visualisation of the recovery status in relation of a specific load can induce the physioterapist to decide to train the patient with that load until the following evaluation test will confirm that the strength deficiency is reduced to a level which permit to pass to an evaluation with a heavier load.

The physioterapist utilizes the *bio-feedback* function of the *SR* app in order to train and monitor the recovery of the strength for a specific load.

Once identified the "training load" for the patient through the above test, the procedure of the *bio-feedback* is based on the acquisition and record of the power expressed during the execution of an exercise (i.e. series of repetitions to the point of exhaustion) performed with the healthy limb by applying the training load to the muscular machine. A average power and a maximum power are obtained and can be respectively set up as work threshold, by choosing also a certain percentage of tolerance, for the patient who will execute the same exercise with the injured limb: the software will visualise in real time the number of repetitions, a coloured histogram which confirms or less that the person is achieving the power level set-up as reference threshold and the percentage of power express in respect of that set-up as threshold.

Further information and/or clarification can be requested to the following company communication channels:

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"Measure what is measurable, and make measurable what is not so"

Galileo Galilei

TECHNOLOGICAL SOLUTIONS for FUNCTIONAL EVALUATIONS

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